



SWP Carbon Sequestration Training Center

Principal Investigators:

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University of Utah, Brian McPherson

Texas A&M University, Tarla Peterson

Background

- ▣ Funded by DOE/NETL.
- ▣ Purpose is to train more scientists and engineers for work in geological sequestration.
- ▣ Three year grant.
- ▣ Designed to be self sustaining.

Our goal is provide education about CCS at a variety of educational levels in order to promote a pipeline of future CCS scientists and engineers.

- ▣ High School
- ▣ K-12 Teachers
- ▣ Undergraduate
- ▣ Graduate
- ▣ Professionals
- ▣ Outreach



Education at multiple levels

- ▣ High School
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High School

- ▣ To interest high students into earth science aspects of CCS, we are offering a one week High School mini-course during the summer.
- ▣ Will introduce students to the types of geology (reservoir and seal rocks) important to geological sequestration
- ▣ Class will have a large field component to look at rocks relevant to sequestration



Education at multiple levels

- ▣ High School
- ▣ **K-12 Teachers**
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K-12 Teachers

- ▣ Introduce climate change
- ▣ Raise awareness of CCS as a career track
- ▣ Give them knowledge to take back to their classrooms (i.e. help them develop lesson plans)
- ▣ Field and lab emphasis
- ▣ Class web page and lectures are developed

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Undergraduate

- ▣ Develop Sequestration Option in the geology degree.
- ▣ Has all core geology classes but includes extra courses in Chemistry, Petroleum Engineering and Hydrology.
- ▣ Will include a senior level class in sequestration to be offered spring 2011



Proposed Courses for Bachelors in Earth Science with Carbon Sequestration Option

- ▣ NMT General degree requirements (includes 1 year calculus, chemistry and physics as well as humanities)

- ▣ *EES Core classes*

- ▣ any EARTH 100 level class and lab

- ▣ EARTH 201 (Bio)

- ▣ EARTH 202 (Surface)

- ▣ EARTH 203 (Crust)

- ▣ EARTH 204 (Whole Earth)

- ▣ EARTH 205 (Earth Science Practicum)

- ▣ EARTH 390 (General Geochemistry)

- ▣ EARTH 325 (Near Surface Geophysics)

- ▣ EARTH 330 (Global Change Hydrology)

- ▣ EARTH 468 (Evolution of Earth)

- ▣ EARTH 483 (Intro to Field Mapping)

- ▣ *Option requirements*

- ▣ PETR 101 (Intro to Petro. Engineering)

- ▣ EARTH 370 (Formation Evaluation)

- ▣ EARTH 440 (Hydrological Theory and Field Methods)

- ▣ EARTH 447 (Depo. Systems & Basin analysis)

- ▣ EARTH 460 (Subsurface and Petroleum Geology)

- ▣ EARTH 484 (Surficial Mapping)

- ▣ EARTH 485 (Metamorphic and Advanced Structure Mapping)

- ▣ EARTH 424 (Sedimentary Petrography)

- ▣ EARTH 4XX (Carbon Sequestration Science)

- ▣ HYD 507/4XX (Hydrogeochemistry)

- ▣ CHEM 331 + 331L (P-Chem)

- ▣ MATH 283 (Statistics)or 382 +382L (Probability)

- ▣

Outreach/ Public Education

- ▣ Web site with educational materials
 - Linked to the general SWP web site
- ▣ Working with k-12 classrooms.
 - Further develop outreach materials started by the SWP
 - Social Science: Survey will compare knowledge and attitudes of students in CCS courses with the general public

Graduate Class Survey

- Survey process includes a pre and post-course survey to determine:
 - Student knowledge and perceptions of CCS before and after the course
 - How to improve the course for the next class offering
- Surveys conducted online using SurveyMonkey®
- Survey questions address:
 - Educational background of enrolled students
 - Course related questions and student interests related to the course layout
 - CCS knowledge questions (ranked)
 - CCS opinion statements (ranked)
 - Demographic information and questions pertaining to where they get their relevant information

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Graduate Class

Class designed to accommodate graduate student from earth science and engineering backgrounds.

This is being taught at in a joint class room between Utah and New Mexico via distance education. Next offering will also include TAMU.

Lectures are by faculty at all three institutions and from other specialists in the field. All lectures and presentations are posted on the class web site



Graduate Class

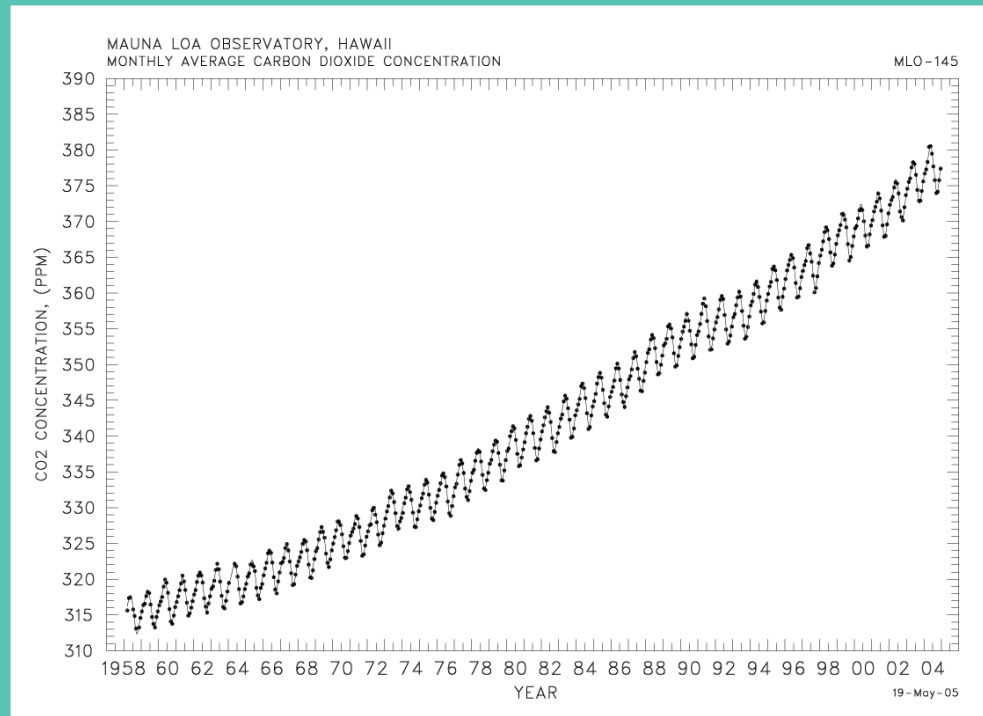
This course is “modular” in design, with six modules:

1. Climate Change
2. Basics of CCS
3. Geology
4. Chemistry
5. Modeling
6. Decision-making
 - MVA
 - Risk Assessment
 - Regulatory
 - Legal/Policy
 - Public Acceptance



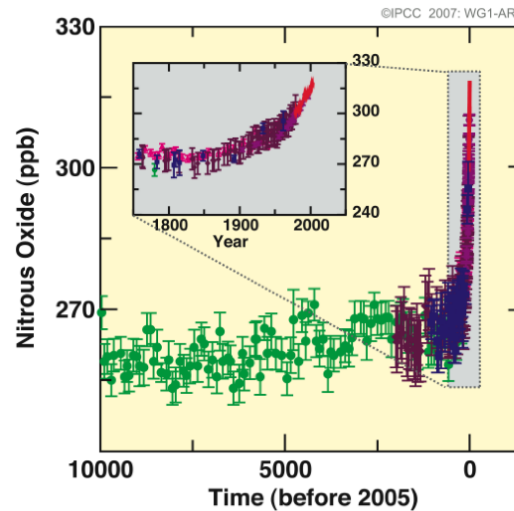
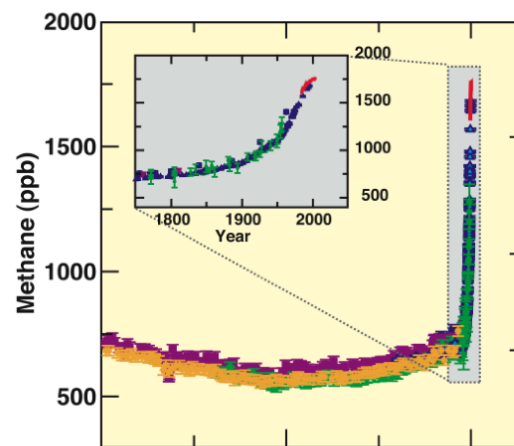
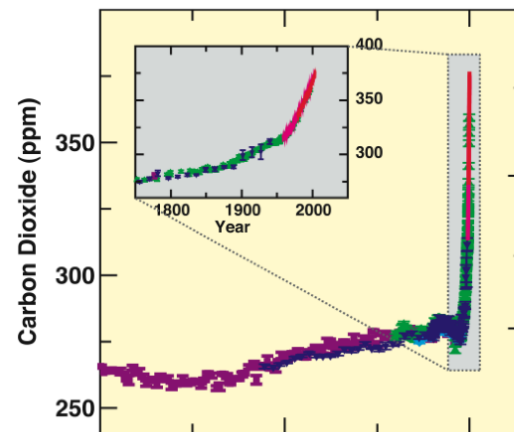
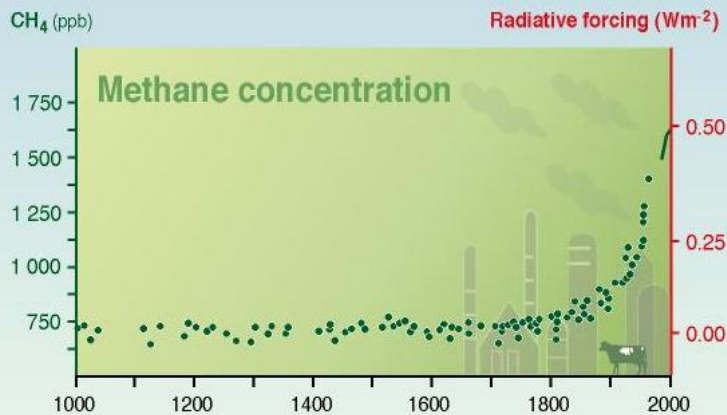
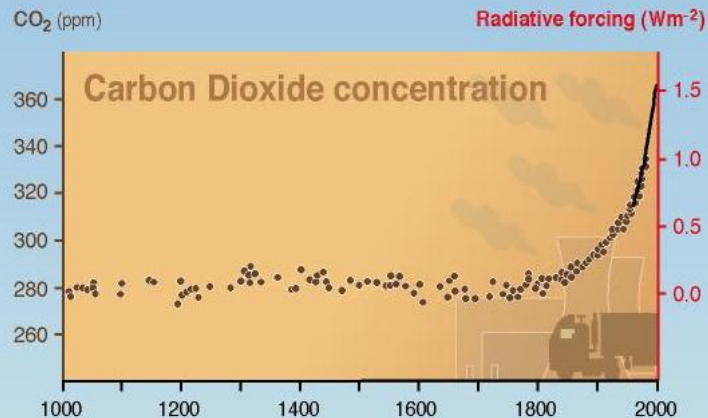
Modern Climate Change

Mauna Loa Carbon Dioxide Record 1957-2004



<http://cdiac.ornl.gov/trends/co2/sio-mlo.htm>

Indicators of the on the atmosphere du

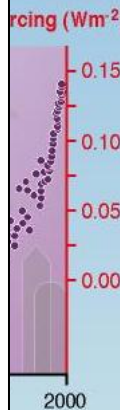


Radiative Forcing (W m⁻²)

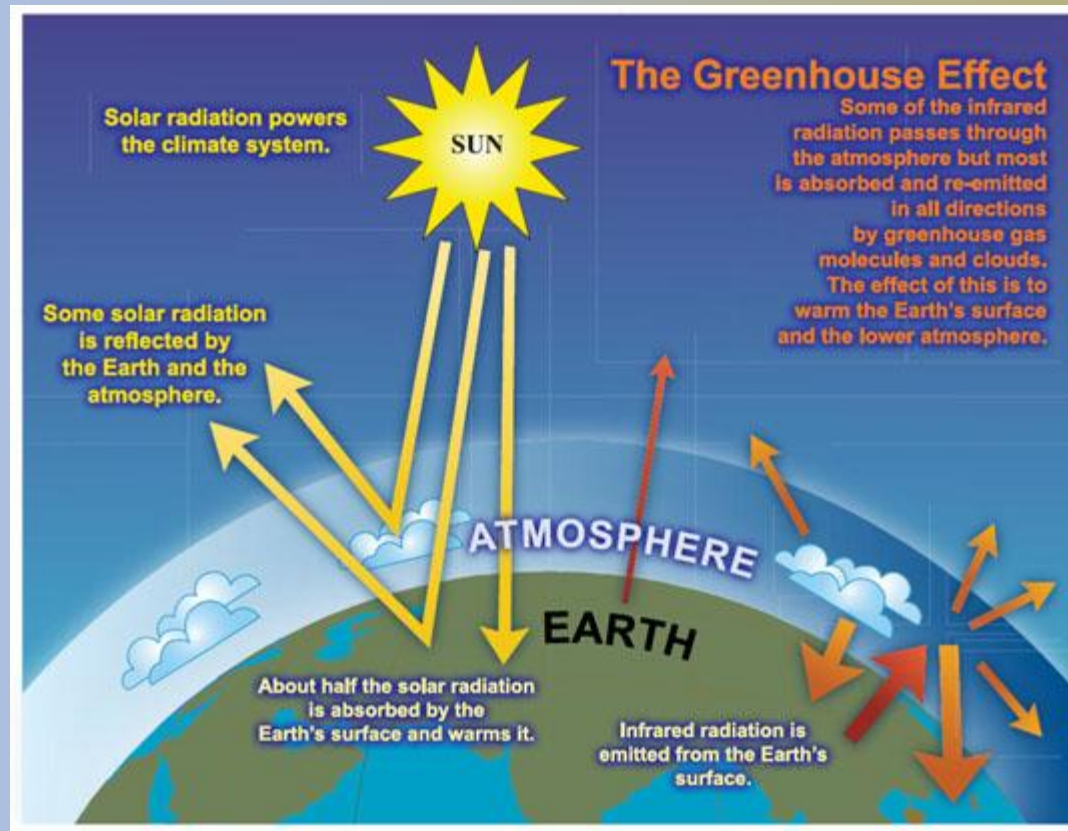
Radiative Forcing (W m⁻²)

Radiative Forcing (W m⁻²)

http://www.ipcc.ch -- Climate Change 2007: Summary for Policymakers

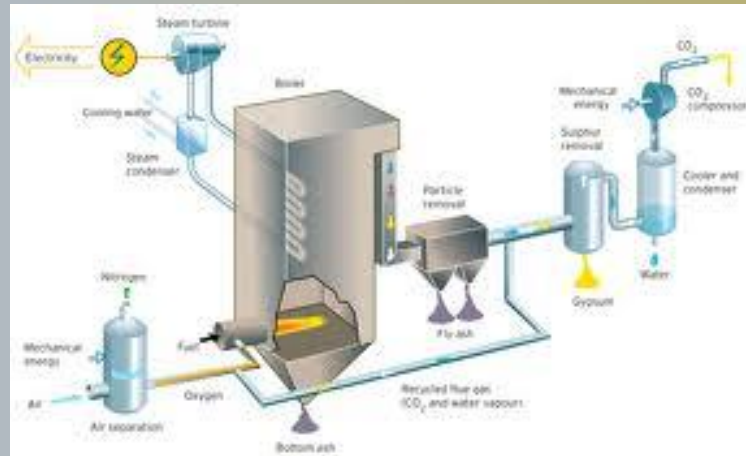


Green House Effect



Basics of CCS

Capture Technology

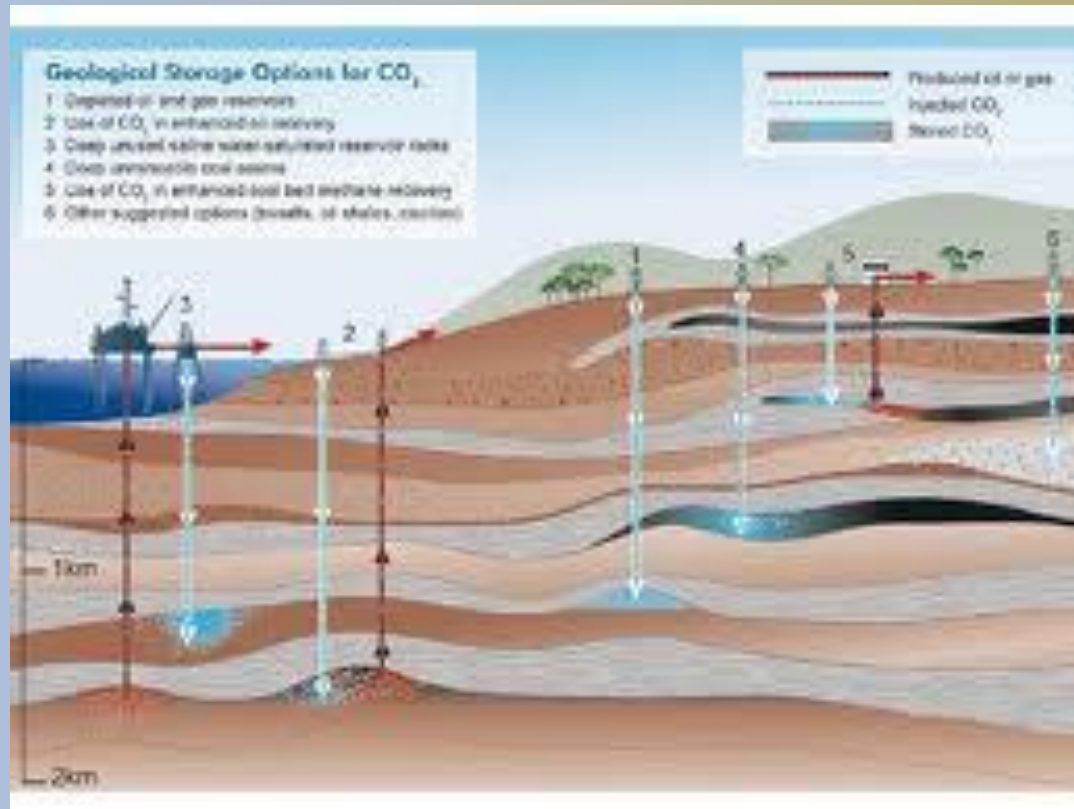


Transportation



Introduction to storage options

Deep saline
EOR
ECBM



Geology

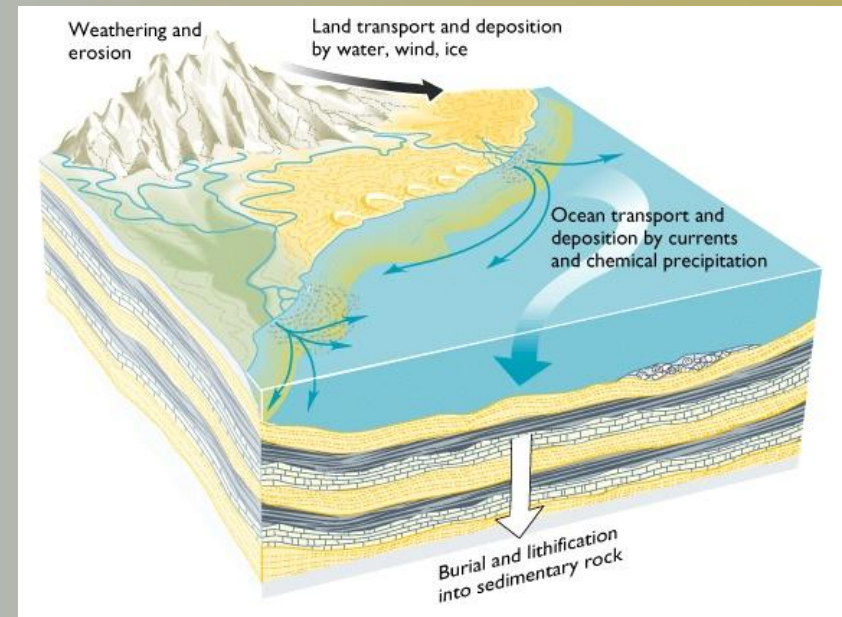
- ▣ This section develop geologic background to understand reservoir and seal rocks.
- ▣ These concepts will be used later in the flow modeling section of the course.
- ▣ Topics range from depositional environments, to pore structures, to mineralogy

Depositional Environments

Fluvial Environment



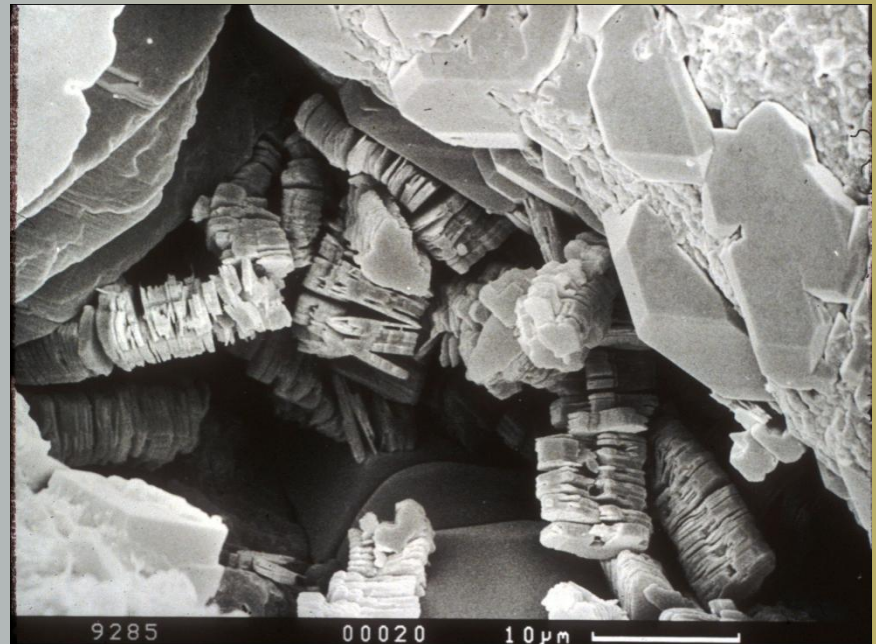
Marine Environments



Outcrop heterogeneity of reservoir and seal rocks

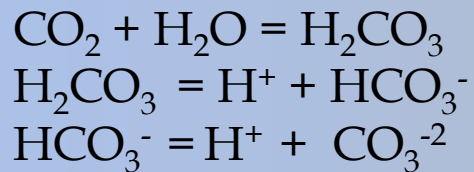


Texture at the small scale
is important for mineral
fluid interaction



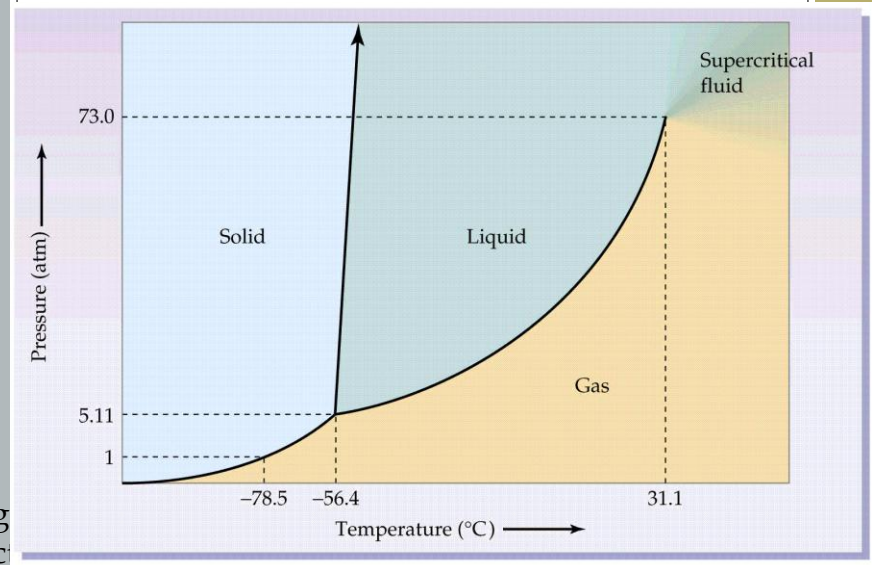
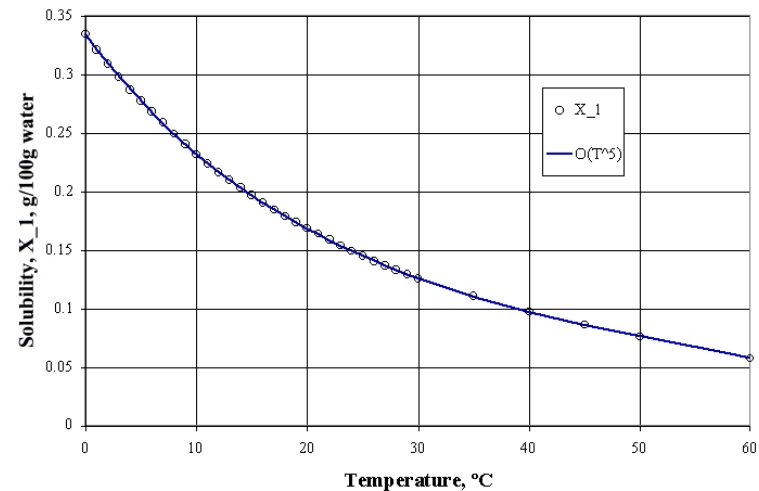
Geochemistry

Aqueous Geochemistry of CO₂



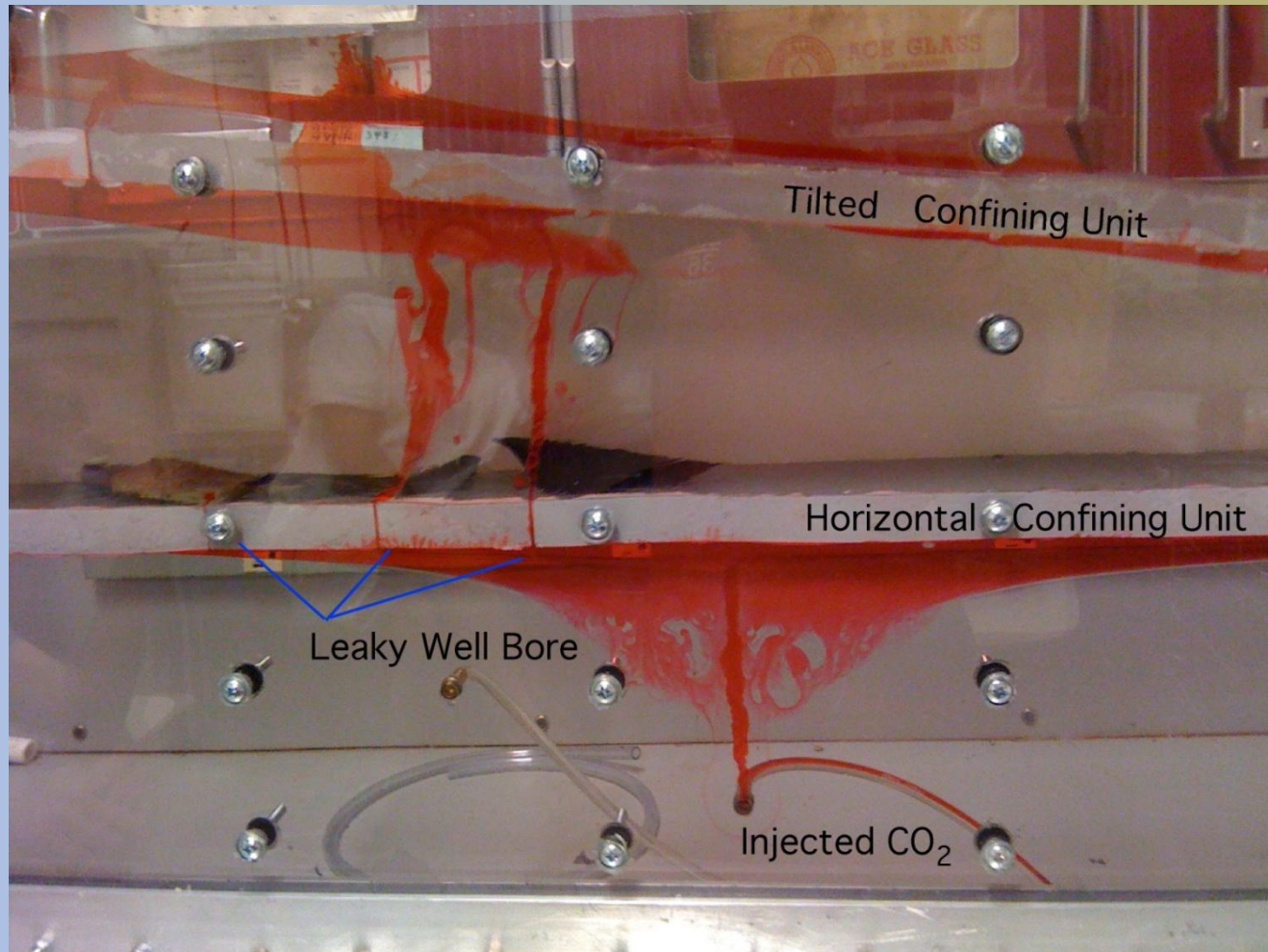
Physical Chemistry of CO₂

CO₂ SOLUBILITY IN WATER

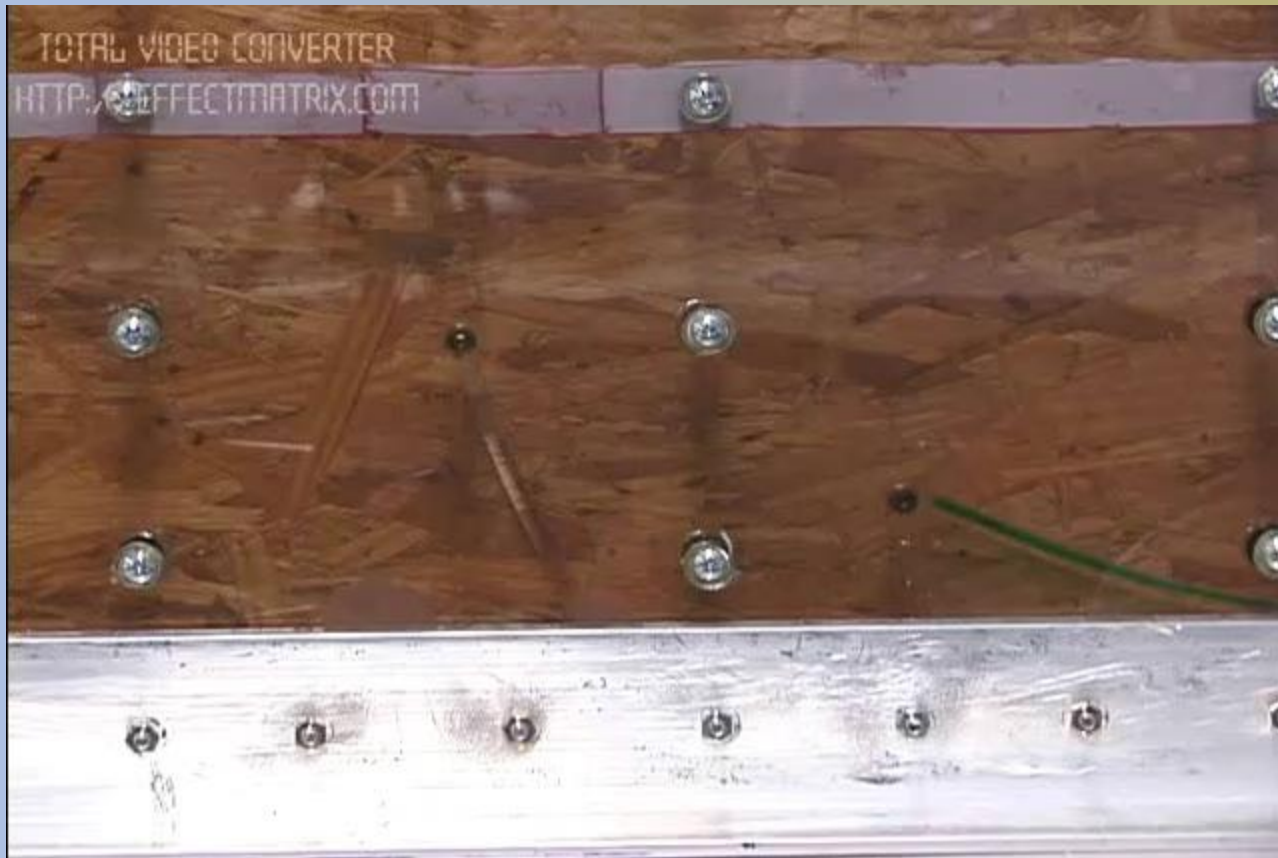


Modeling of Subsurface flow

Hele-Shaw cell model of a leaky confining layer



SWP Training Center Presentation,
October 2010



Other Topics

- ▣ Monitoring and Verification
- ▣ Risk
- ▣ Policy
- ▣ Regulatory issues
- ▣ Economics
- ▣ Public Perception

Synthesis: Moot Court

- ▣ Assignment for the course include researching and defending various topics in a Court room formant
- ▣ Class is divided into three teams
- ▣ Each team must defend its position and work up arguments against (“prosecute”) the other positions
- ▣ A Jury of instructors rules on a winner.
- ▣ Court is run by a Judge

Synthesis: Moot Court

No. 2

In the Fake Court of the Carbon Capture and Storage

ENHANCED COAL-BED METHANE, LTD.,
PETITIONER,

v.

ENHANCED OIL RECOVERY,
DEEP SALINE SEQUESTRATION,
RESPONDENTS.

BRIEF

Kristine Blickenstaff, Wei Jia, Aleksandra Opara, Vivek Patil, Justin Wriedt, Oscar Zabala
Counsels for the Petitioner

October 1, 2010

SWP Training Center Presentation,
October 2010

Synthesis: Moot Court

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TEAM OF COUNSELS

The team of counsels consists of two advocates of the enhanced coal-bed methane sequestration, two prosecutors of the competing sequestration technologies and two defense lawyers. Each team member was responsible for learning the general information about all sequestration technologies and thoroughly researching the specific task he or she was assigned.

Vivek Patil is an advocate of the enhanced coal-bed methane sequestration based on technical advantages. Oscar Zabala is the second advocate for the enhanced coal-bed methane sequestration based on other advantages. Kristine Blickenstaff is the prosecutor of the enhanced oil recovery sequestration and Justin Wriedt is the prosecutor of the deep saline carbon sequestration. Wei Jia is the defense lawyer of the technical and the non-technical aspects of the enhanced coal-bed methane sequestration. Aleksandra Opara is the leading case attorney.

STATEMENT OF THE CASE

In the case brought in front of the Court today, we argue that enhanced coal-bed methane is superior to other carbon sequestration methods, in respect to technical aspects and otherwise.

Factual Background

Enhanced coal-bed methane (ECBM) is the process of injecting CO₂ gas into a coal seam, which increases the recovery of methane from coal [White et al., 2005]. Carbon dioxide is physically adsorbed to coal in a similar manner in which activated carbon removes impurities from air or water [Herzog, 2001]. CO₂ is preferentially adsorbed on the coal structure over methane and at least two molecules of carbon dioxide can be adsorbed for every methane molecule that was released [Hamelinck et al., 2002; Harpalani et al., 2006].

Synthesis: Moot Court

QuickTime™ and a
H.264 decompressor
are needed to see this picture.

Moot Court Topics

- ▣ Capture Technology
 - Post-combustion vs. Pre-combustion vs Oxy-combustion
- ▣ Storage type
 - EOR vs ECBM vs Deep Saline
- ▣ Multiphase Flow and Fluid Pressure Transfer
 - reservoir or aquifer vs. seal or aquitard vs. faults and fractures

Moot Court Topics

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Professional

- ▣ We will introduce material relevant to working professional for advanced training or retraining into geological sequestration
 - Short Courses
 - Seminars

- ▣ Material for the professional short courses based on integration of secondary, undergraduate and graduate curricula (these are all “modular”)

- ▣ All short courses will be accredited (CEUs / PDUs) and will be offered live initially and via webcast subsequently

Professional

- ▣ All short courses will be accredited (CEUs / PDUs) and will be offered live initially and via webcast subsequently
- ▣ First short course: CCS Simulation Analysis / STOMP Workshop – October 26 & 27, at the University of Utah in Salt Lake City. Lead by Mark White and Signe Wurstner of PNNL and hosted by the SWTC.

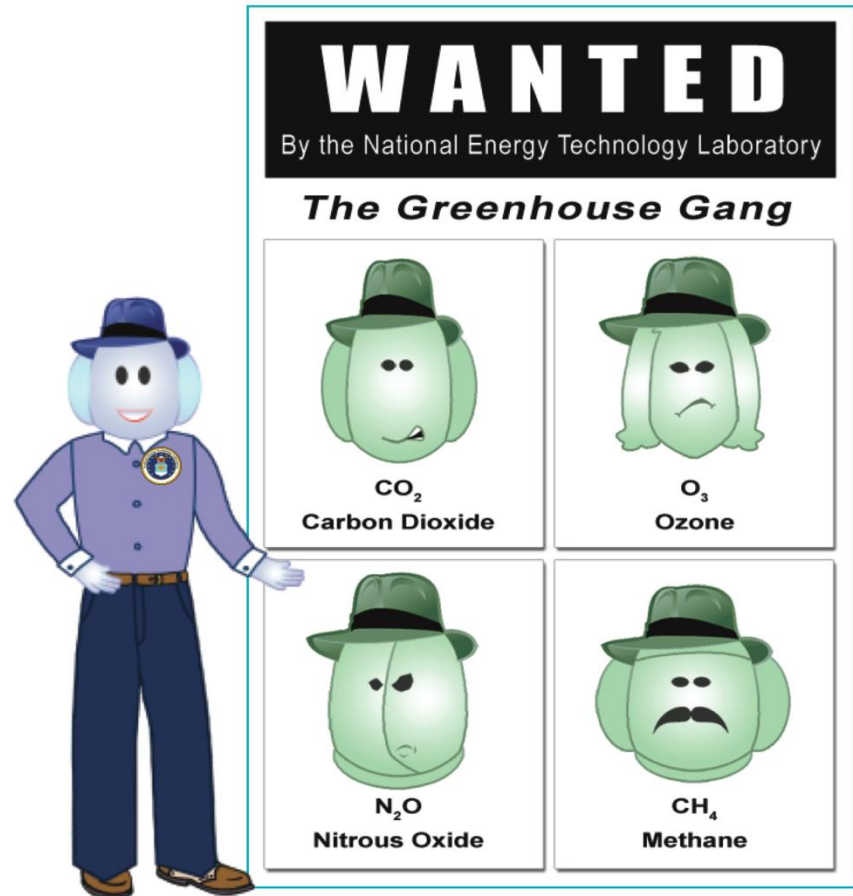
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Outreach and Education

- ▣ Outreach activities begun under auspices of the SWP will continue in earnest by the SWTC:
 - Town halls
 - Tech alerts
 - Surveys
 - Newsletters
 - Workshops
 - Pedagogical research

OUTREACH/PUBLIC EDUCATION



Our web site includes educational materials geared towards K-12 students and the general public.



SWP Carbon Sequestration Training Center

Any Questions??